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(54) Abstract Title
Workpiece support device

(57) A workpiece support device comprises an array of rods (2) in columns and rows with free ends of the rods forming a support surface, in which support surface recesses can be created by selectively retracting individual ones of the rods (2). Each rod (2) is coupled to a respective piston (3) within a respective cylinder (1) and each cylinder (1) in a row has an upper connection (4) for medium pressure and a lower connection (7) for high pressure. Each cylinder in a column has a middle connection (8) for low pressure. A trigger piston (5) is provided in a cylinder (6) below the piston (3). The rod (2) can be caused to extend from the cylinder (1) by applying low pressure to the connection (8) to press the trigger piston (5) downwardly to close the high pressure connection (7). Such low pressure passes around the lip of a lip seal 24 on the trigger piston 5 and through a connection 28 pressurises the underside of the piston 3 to raise the piston 3 and release it from pressing the trigger piston 5 downwardly. Subsequently pressurising the connections (4) and (7) causes the differential pressure to force the piston (3) upwardly. However by sequencing the application of pressure to the connections (4, 7 and 8) the rod (2) can be locked in the retracted position. Medium pressure applied to the connection (4) presses the piston (3) downwardly to abut the trigger piston (5) and hold it in a depressed condition in which it will remain even after pressure is restored to the high pressure connection (7).

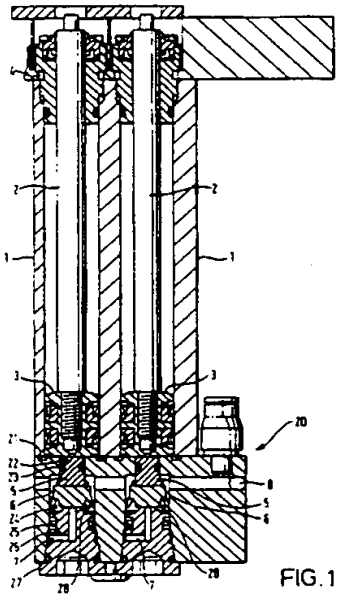

FIG.1

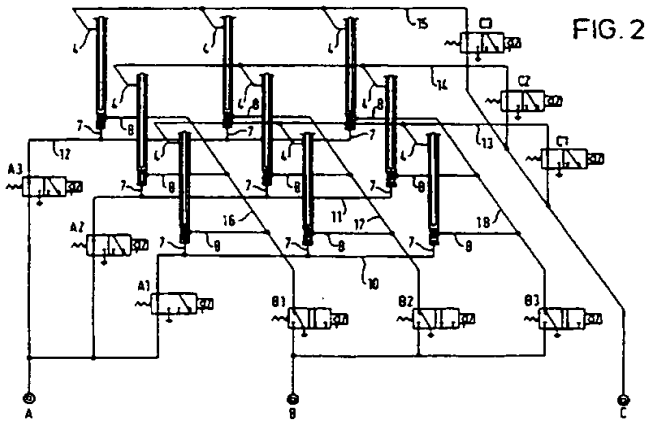

FIG.2

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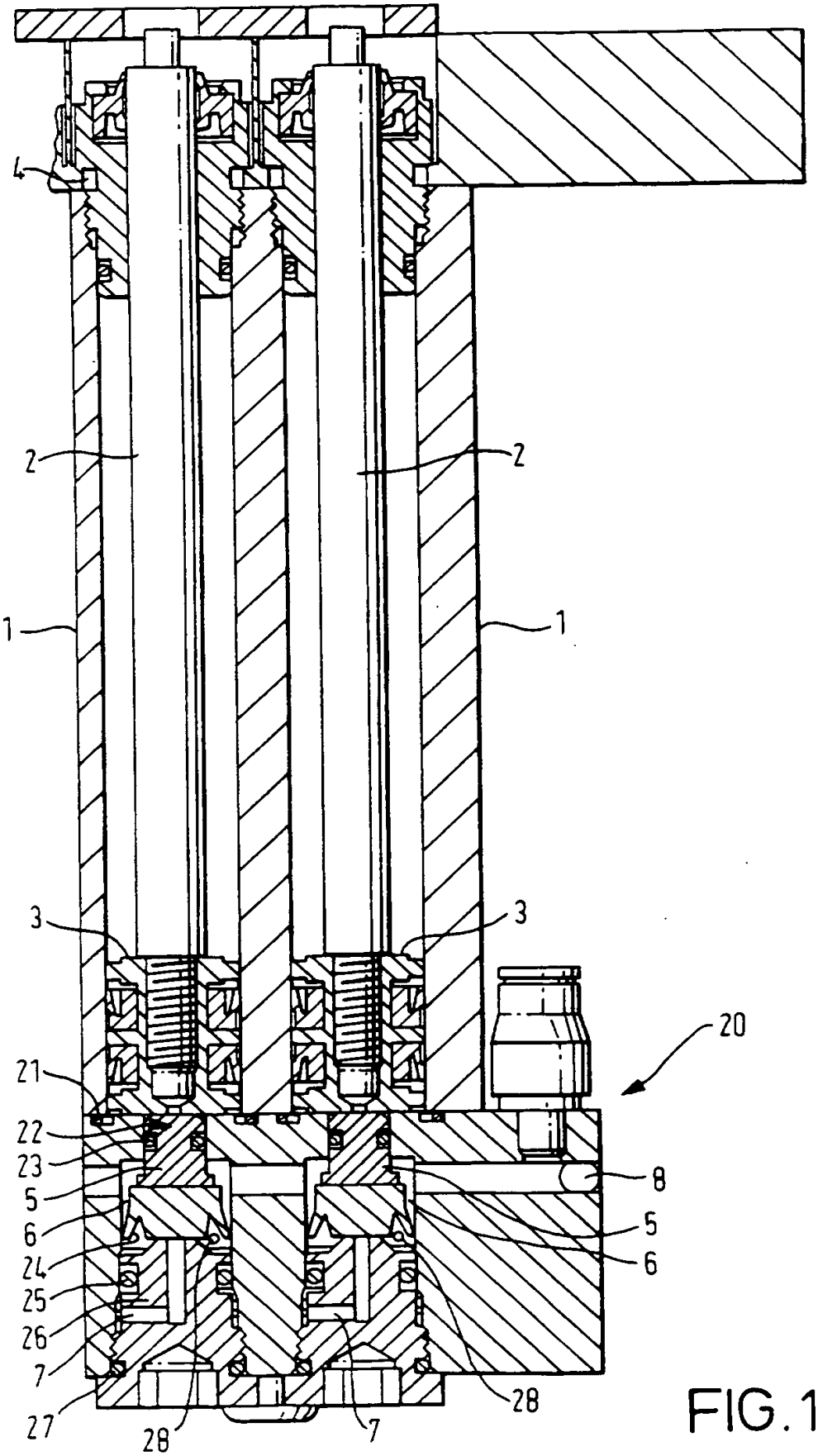


FIG.1

FIG. 2

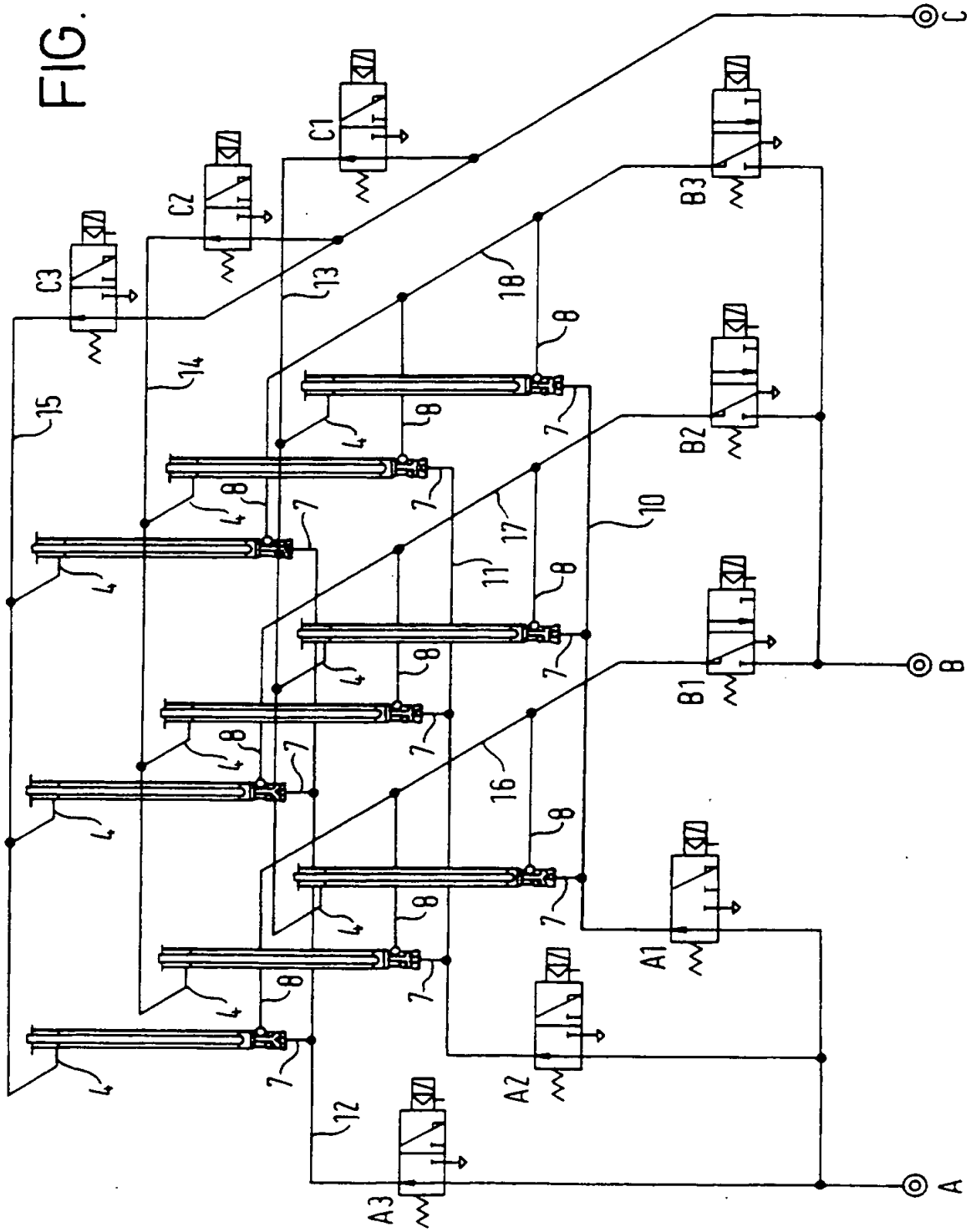
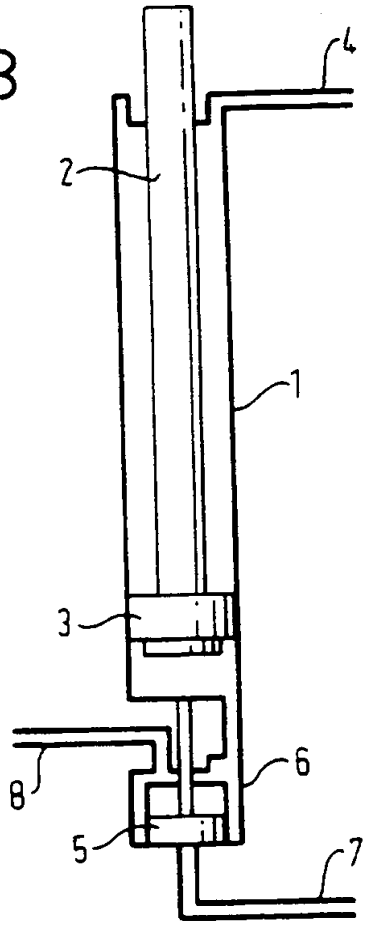


FIG.3



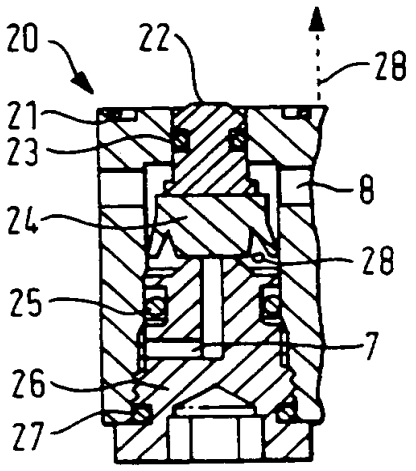
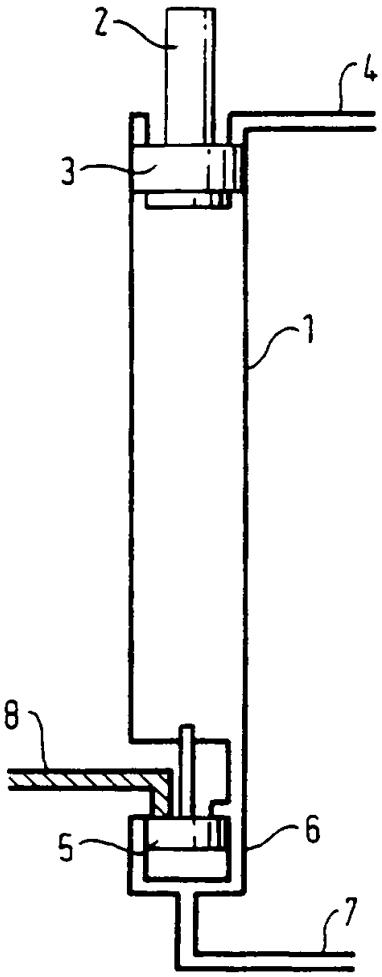


FIG.3a

FIG. 4



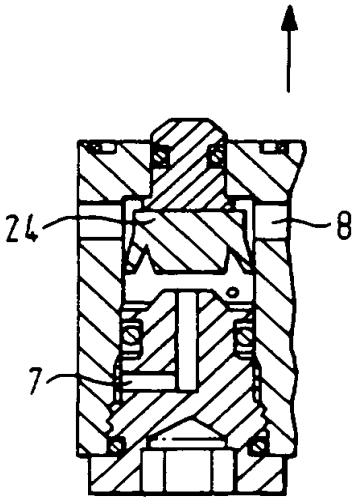
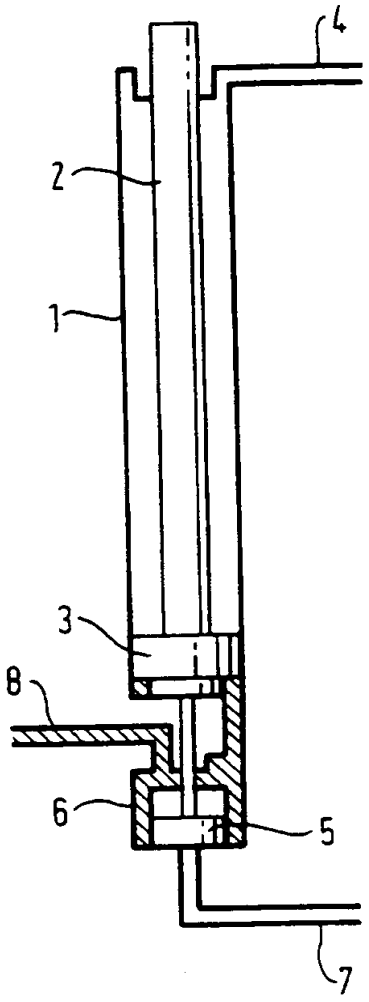


FIG. 4a

FIG. 5



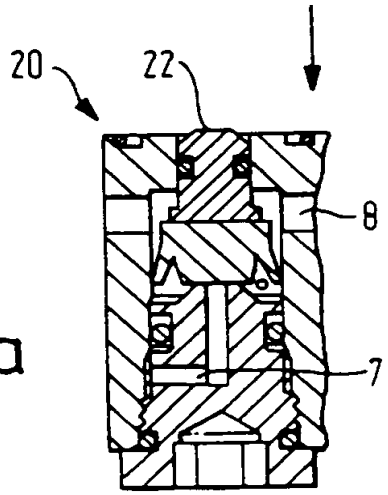
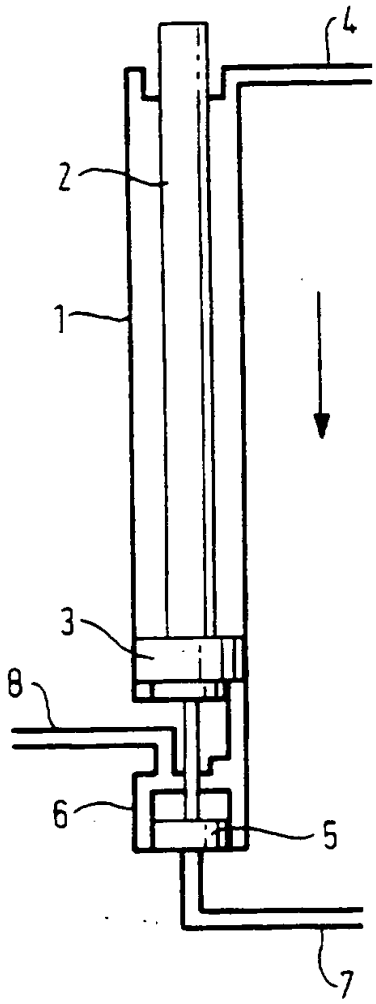


FIG.5a

FIG.6



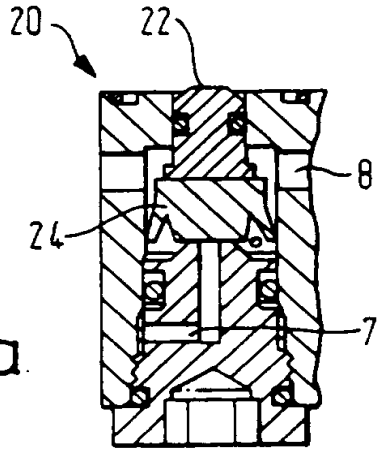
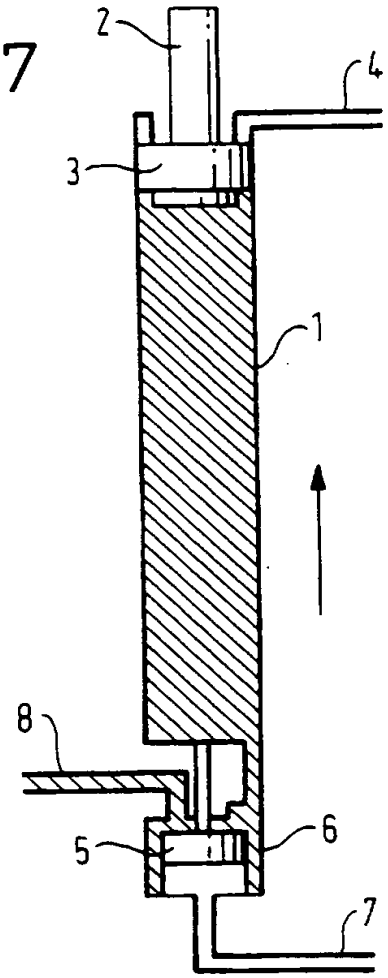


FIG.6a

FIG. 7



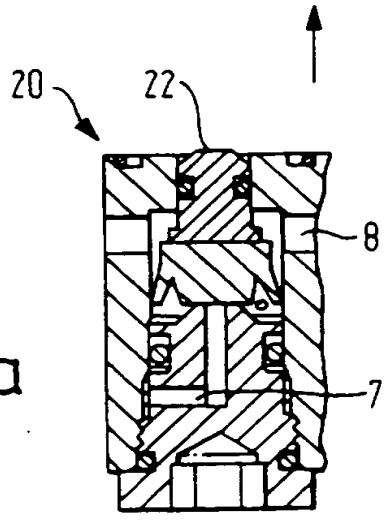
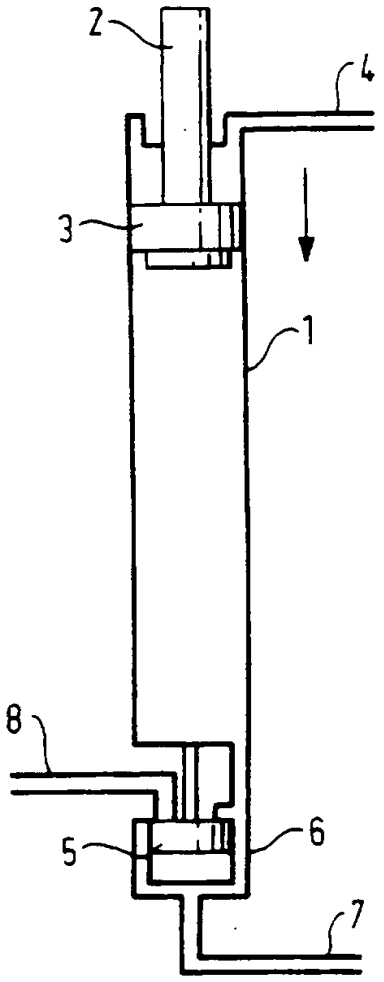


FIG. 7a

FIG.8



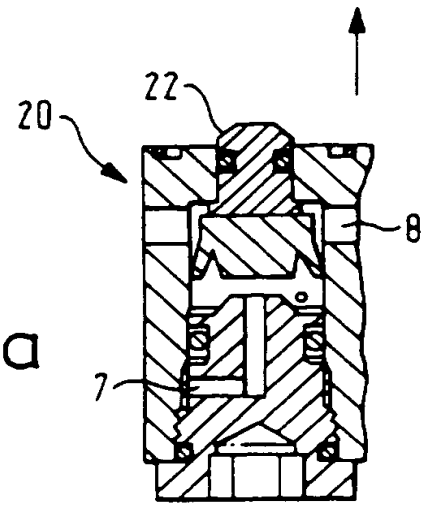
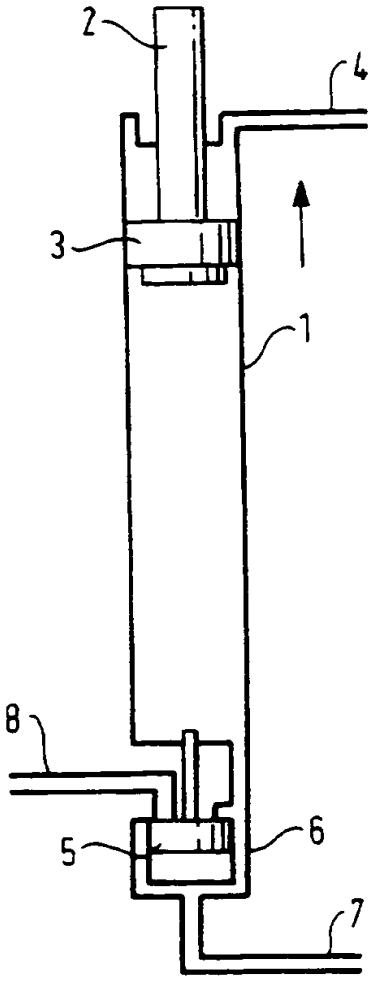


FIG.8a

FIG. 9



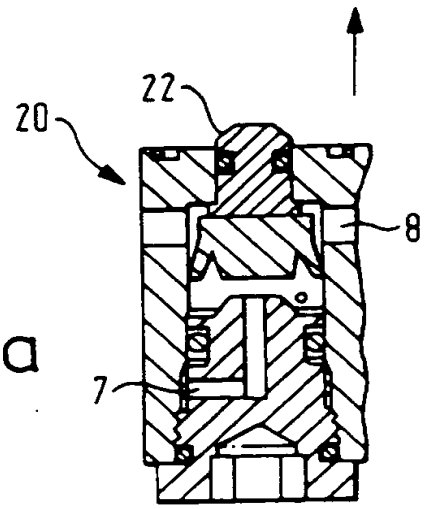


FIG. 9a

FIG. 10

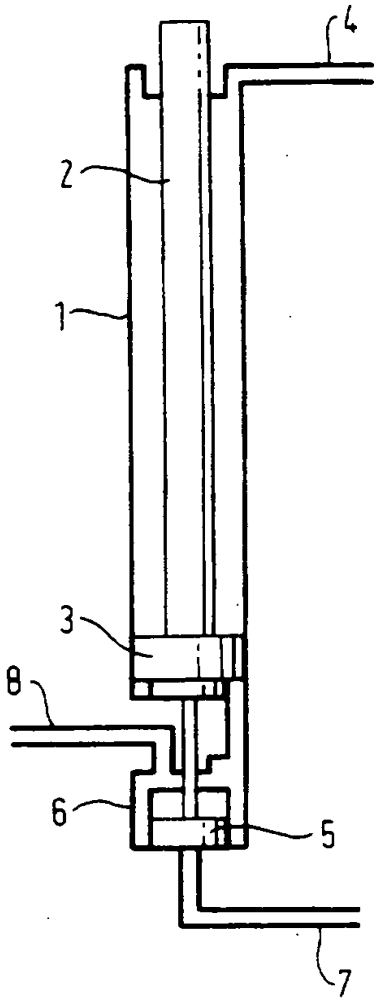


FIG. 11

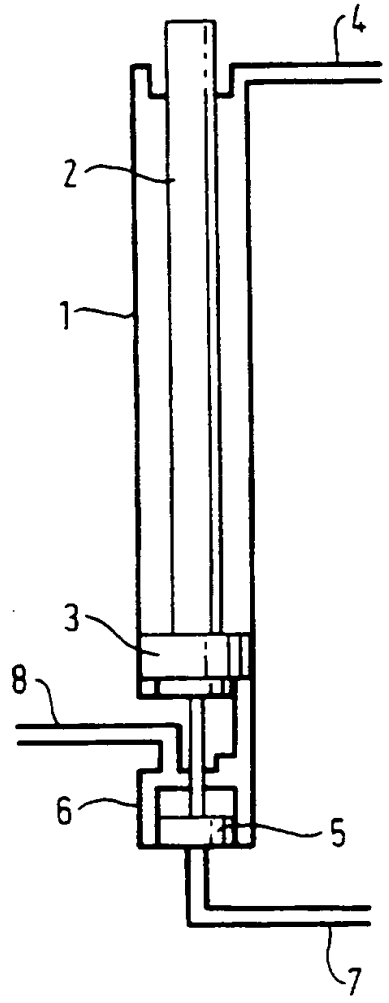
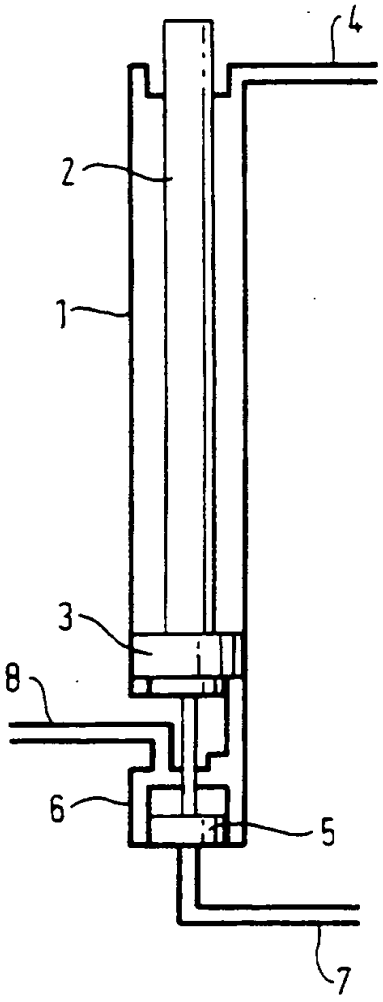


FIG. 12



WORKPIECE SUPPORT DEVICE

The invention relates to a workpiece support device.

A plurality of parallel rods can be provided in an array of columns and rows with free ends of the rods lying either in a plane which defines a support surface or alternatively retracted therefrom to form a recess in the support surface. A workpiece on which an operation is to be performed can be supported by the support surface even though it has projections on the face which is towards the support surface since such projections can be accommodated in the recesses formed by retracted ones of the rods. The workpiece may for example be a printed circuit board which already carries circuit components on one side and the other side of which is to have an operation effected thereon such as a printing operation, solderflow to secure the circuit components or affixing of further circuit components on the opposite side to the first circuit components. Since a very large number of rods may be desirable to form the support surface, for example an array of 44 columns and 44 rows giving a total number of 1936 rods, it is desirable that the individual rods and mounting and moving means therefor can be located close together and can be set to an advanced position or a retracted position rapidly and reliably.

According to the invention a workpiece support device comprises an array of rods in columns and rows with free ends of the rods forming a support surface, in which support surface recesses can be created by selectively retracting individual ones of the rods, wherein each rod is coupled to a respective piston within a respective cylinder, all the cylinders in each row have their upper ends connected to a medium pressure source via a respective valve and their lower ends connected to a high pressure source by a further respective valve, a trigger piston is provided in the lower end of each cylinder and is movable between a raised position in which it allows the high pressure source to feed the bottom of the cylinder and a lowered position in which it closes off the feed from the high pressure source and allows feed to the bottom of the cylinder from a low pressure source connected to the cylinders of each column by a respective still further valve, each piston can be locked in an advanced position by differential pressure between the medium and high pressure sources and

can be locked in a retracted position by causing that piston to hold the respective trigger piston in the lowered position.

The pressure sources are preferably pneumatic and by choosing a suitable sequence of application of pressure to the upper end of the cylinder and the lower end of the cylinder from the low, medium and high pressure sources by the respective row valves and column valves, the pistons of the rows and columns can be set individually to advanced or retracted positions as desired.

Preferably the row valves feeding the upper ends of the cylinders and the row valves feeding the lower ends of the cylinders are normally open valves and the column valves feeding the lower ends of the cylinders are normally closed valves. Each row valve when not in its normal position vents the portion of the cylinder to which it is connected to atmosphere.

The device can be set for a desired shape of workpiece by setting the cylinders of the rows individually and sequentially until all the rows required for the workpiece are set. Each row is set by energising the valve and further valve supplying the upper and lower ends of the cylinder (thereby depressurising the areas of the cylinder to which they are connected) and energising the still further valve of the columns corresponding to cylinders required to be extended (thus applying air pressure to the lower end of the cylinder from the low pressure source). Such air applied by the still further valve depresses the trigger piston and raises the cylinder piston to the extended position of the rod. When the air pressure applied to the further respective valve is removed and air pressure is again applied to the upper and lower row connections through the valve and the further valve, the high pressure to the lower connection raises the trigger piston and is applied to the underside of the main piston to force the rod to a fully extended position due to the differential pressure between the medium pressure source and the high pressure source.

In the columns in which the rod is not to be extended, the still further valve connected to the low pressure source at the lower end of the cylinder is not opened, the main piston is therefore not raised and when the upper medium pressure valve is opened the main piston is forced downwardly to depress the trigger piston and close the high pressure connection. The high pressure, when reconnected, is insufficient

to raise the trigger piston against the downward force applied by the medium pressure to the main piston and the rod remains in the retracted position.

All cylinders may be reset to the retracted position by exhausting all the bottom connections while maintaining the air supply to the top connections and can then be set to advanced position or maintained in retracted position as desired. By the choice of valve types (either normally open or normally closed), it can be arranged so that when all the valves are de-energised the apparatus maintains its current set up.

The invention is diagrammatically illustrated by way of example in the accompanying drawings in which:-

Figure 1 is a sectional illustration of two adjacent cylinders of a workpiece support device according to the invention;

Figure 2 is a schematic diagram showing pneumatic connections to an array of pneumatic cylinders in three rows and three columns forming a workpiece support device according to the invention;

Figure 3 is a view showing one of the cylinders of the array of Figure 2;

Figure 4 shows the cylinder in a locked up position;

Figure 5 shows the cylinder in a locked down position;

Figure 6 shows the cylinder in a resetting condition;

Figures 7, 8 and 9 show successive steps in a setting operation to set the piston of the cylinder in an up position;

Figures 3a to 9a respectively show the arrangement and position of a trigger piston provided in the cylinder for each of the conditions of Figures 3 to 9; and

Figures 10, 11 and 12 show successive steps to set the cylinder with the piston in a down condition.

Referring to the drawings and firstly to Figure 1, each of the two cylinders 1 shown has a piston rod 2 therein mounting a piston 3 at its lower end. The usual seals are provided. At the upper end there is an inlet connection 4. At the lower end, below the piston 3, a trigger piston 5 is provided aligned with the rod 2 and the piston 3 of the cylinder 1 but contained within its own cylinder 6. The bottom end of the piston 3 can abut the top end of the trigger piston 5. A high pressure

connection 7 is provided to the underside of the trigger piston 6 and a low pressure connection 8 is provided to the upperside of the trigger piston 6.

Referring to Figure 2, nine of the cylinders 1 are shown in an array of three rows and three columns. The high pressure connections 7 of the bottom row are connected to a line 10 which is connected to a high pressure source A, for example 10bar by a normally open valve A1. Likewise a line 11 connects the connections 7 of a middle row of the cylinders 1 via a valve A2 to the high pressure source A and a line 12 connects the connections 7 of the upper row of cylinders to the high pressure source A via a valve A3.

In similar manner the connections 4 at the upper ends of the cylinders of the bottom row are connected by a line 13 and a normally open valve C1 to a medium pressure source C, the connections 4 of the middle row via a line 14 and a valve C2 to the source C and the connections 4 of the upper row via a line 15 and a valve C3 to the source C.

The connections 8 at the lower end of the cylinders above the trigger pistons 6 of the left-hand column of the cylinders 1 are connected by a line 16 and a normally closed valve B1 to a source of low pressure B, the connections 8 of the cylinders 1 of the middle row by a line 17 and a valve B2 to the source B and the connections 8 of the right-hand column by a line 18 and a valve B3 to the low pressure source B.

Thus for example the pressure of the source A is normally applied to the connections 7 of the cylinders but can be cut off row by row by individually operating, i.e. closing, the valves A1, A2, A3, likewise the medium pressure source C is normally applied to the upper ends of the cylinders 1 but can be selectively cut off row by row by individually operating, i.e. closing, the valves C1, C2 and C3, but the low pressure from the source B is not normally applied to the upper ends of the trigger pistons of the cylinders but can be applied thereto column by column by selectively operating, i.e. opening, the valves B1 and B2 and B3.

Referring to Figure 3 the components described with reference to Figure 1 of a piston cylinder arrangement can be seen, particularly the cooperating piston 3 and trigger piston 5 and the low pressure connection 8, the medium pressure connection

4 and the high pressure connection 7.

In Figures 1 and 3a can be seen an interpilot mechanism 20 comprising not only the trigger piston 5 in its cylinder 6, but an interpilot lip seal 24 which acts in the bore of the cylinder 6 and can move longitudinally therein with low friction. The remainder of the piston 5 is formed by a push pin 22 sealed by an 'O' ring 23 in a bore which extends between the cylinder 6 and the main cylinder 1. Below the interpilot lip seal 24 is an orifice plug 26 sealed by an 'O' ring 25 above the high pressure connection 7 and by an 'O' ring 27 below the high pressure connection 7. An 'O' ring 21 (also shown in Figure 1) seals the interpilot mechanism 20 to the lower end of the main cylinder 1. A connection 28 leads from below the interpilot lip seal 24 to the bore of the cylinder 1. The orifice plug 26 is screwed into the cylinder 6 from below and sealed by the two 'O' rings 25, 27. After the plug 26 has been removed, the lip seal 24 and push pin 22 can readily be removed also together with the 'O' ring seal 23.

Figure 4 shows that the piston cylinder arrangement can be locked up i.e. held locked in the piston advanced position by applying pressure to both the connections 4 and 7, it is irrelevant whether pressure is applied or not applied to the connection 8. Likewise Figure 5 shows that the piston cylinder arrangement can be locked down i.e. held locked in the piston retracted position by applying pressure to the connections 4 and 7 and again it is irrelevant whether pressure is being applied or not applied to the connection 8. Thus it depends upon the sequence of the application of pressure to the three connections of each cylinder which moves the cylinder to the advanced or to the retracted position and once it has achieved that position it will be held therein by application of pressure to the ports 4 and 7.

Thus if pressure is first applied to the connection 4 the piston 3 will move downwardly and apply downward pressure to the push pin 22 to press the lip seal 24 against the orifice plug 26. This closes the connection 7 and prevents the high pressure reaching the main piston bore. The compression of the interpilot seal 24 produces a reactive "spring" force, which when released, assists with moving the piston 3 via the pin 22 when it is signalled to lift.

Lifting of the piston 3 and rod assembly is achieved by applying pressure to

the connection 8. By the nature of the interpilot seal 24 air can flow around the outside of the seal 24 compressing the lip radially inwards and allowing the air to connect with the lower side of the piston 3 via the connection 28. This pressure and the force generated by the seal compression drive the piston 3 and rod upwards toward the locked up position of Figure 4.

At the same time the high pressure is also acting on the lower face of the interpilot seal 24 and this pushes the interpilot seal 24 away from the orifice plug 26 seat allowing the high pressure air to enter the piston bore via the connection 28. The high pressure has two further effects. 1) to expand the lip of the interpilot seal 24 which effectively reseals the connection 8 and prevents the high pressure air from entering the upper chamber of the cylinder 6 and 2) allows the high pressure air to act on the full lower face of the interpilot seal 24 to drive the mechanism upward under power. In this way high forces act on the interpilot seal 24 in both the locked up and locked down positions substantially reducing the chance of frictional errors occurring.

Figure 6 shows that a piston cylinder arrangement can be reset to the retracted position by applying pressure to the connection 4 with the connections 7 and 8 being open to atmosphere. Thus resetting of the piston 3 and rod assembly is achieved in that the exhaust air initially passes through to the orifice of the interpilot plug 26 (now set at zero pressure) and finally via the upper chamber of the cylinder 6 (now set at 0bar). The latter is possible since the interpilot lip seal 24 overlaps the hole of the connection 28 effectively by-passing the interpilot seal 24.

From the position of Figure 6 any piston cylinder arrangement in the array can be set to the advanced position by the sequence of operation shown in Figures 7, 8 and 9 or alternatively can be set to the retracted position by the sequence of operations shown in Figures 10, 11 and 12.

Overall the workpiece holding device can be set for a particular workpiece by setting one row of cylinders at a time sequentially until all the rows required for the workpiece are set.

With reference to Figure 7 to set a cylinder to the advanced position firstly the valves A and C are energised to remove the pressure sources from the connections

4 and 7 and open them to atmosphere. Pressure is applied by opening the respective column valves to cause the source B to supply pressure to the connections 8. This pressure passes around the edge of the lip seal 24 and through the connection 28 to the underside of the piston 3 to raise the piston 3 and the rod 2 to the advanced position as shown by the arrow. As shown in Figure 8 de-energisation of the respective valve feeding the connection 4 applies pressure to the connection 4 to start the piston 3 moving downwardly but de-energisation of the valve feeding the connection 7 applies pressure to the connection 7 and via the connection 28 rapidly moves the piston 3 upwardly to the locked up position of Figure 4.

To set a cylinder to the retracted position the sequence shown in Figures 10, 11 and 12 is followed. Initially it can be seen in Figure 10 that the cylinder is in the resetting condition achieved by Figure 6 and that the pressure connection to the connection 4 has been switched off. It is subsequently switched on again as shown in Figure 11 forcing the piston 3 downwardly to engage the trigger piston 5 thereby closing the pressure input from the connection 7. Even when the pressure is re-applied to the connection 7 as shown in Figure 12 the piston is maintained in the downward position since the force of the high pressure connection acting on a small area of the underside of the trigger piston 5 is insufficient to overcome the action of the lower pressure from the connection 4 acting on the much larger area of the upperside of the piston 3.

Thus the cylinders of the rows are sequentially set to desired positions and as each row is set its cylinders are locked into position by the application of air at high pressure to the lower connection 7 and air at medium pressure to the top connection 4, the middle connection being exhausted to atmosphere. Since the base of each retracted piston 3 touches the top of the trigger piston 5 at the base of the cylinder 1, it pushes it down to seal off the entry of air at the high pressure connection 7. Since the pistons which are extended do not touch the respective trigger piston 5, the respective trigger piston is forced upwardly and the high pressure from the connection 7 is applied via the connection 28 to the underside of the piston 3 to retain it in the advanced position. When desired, all the cylinders can be reset to the retracted position by exhausting the connection 8 and the connection 7 while applying pressure

to the connection 4.

While the device has been described as in an orientation in which the free ends of the rods form a horizontal surface facing upwardly on which a workpiece can be supported, this has been done merely for ease of description. The orientation of the device is not so limited but could be any other orientation and terms such as "upper" and "lower" which have been used in the description for convenience should be amended accordingly to reflect the changed orientation. Any number of rows and columns can be used to obtain a support surface of a desired size and shape, as described the number of valves required will be twice that of the number of rows plus the number of columns.

CLAIMS

1. A workpiece support device comprising an array of rods in columns and rows with free ends of the rods forming a support surface, in which support surface recesses can be created by selectively retracting individual ones of the rods, wherein each rod is coupled to a respective piston within a respective cylinder, all the cylinders in each row have their upper ends connected to a medium pressure source via a respective valve and their lower ends connected to a high pressure source by a further respective valve, a trigger piston is provided in the lower end of each cylinder and is movable between a raised position in which it allows the high pressure source to feed the bottom of the cylinder and a lowered position in which it closes off the feed from the high pressure source and allows feed to the bottom of the cylinder from a low pressure source connected to the cylinders of each column by a respective still further valve, each piston can be locked in an advanced position by differential pressure between the medium and high pressure sources and can be locked in a retracted position by causing that piston to hold the respective trigger piston in the lowered position.

2. A workpiece support device according to claim 1, in which the pressure sources are pneumatic.

3. A workpiece support device according to claim 1 or claim 2, in which the row valves feeding the upper ends of the cylinders and the row valves feeding the lower ends of the cylinders are normally open valves and the column valves feeding the lower ends of the cylinders are normally closed valves.

4. A workpiece support device according to claim 3, in which each row valve when not in its normal position vents the portion of the cylinder to which it is connected to atmosphere.

5. A workpiece support device according to any one of claims 1 to 4, in which

the device can be set for a desired shape of workpiece by setting the cylinders of the rows individually and sequentially until all the rows required for the workpiece are set.

6. A workpiece support device according to claim 5, in which each row is set by energising the valve and further valve supplying the upper and lower ends of the cylinder (thereby depressurising the areas of the cylinder to which they are connected) and energising the still further valve of the columns corresponding to cylinders required to be extended (thus applying air pressure to the lower end of the cylinder from the low pressure source), such that air applied by the still further valve depresses the trigger piston and raises the cylinder piston to the extended position of the rod, when the air pressure applied to the further respective valve is removed and air pressure is again applied to the upper and lower row connections through the valve and the further valve, the high pressure to the lower connection raises the trigger piston and is applied to the underside of the main piston to force the rod to a fully extended position due to the differential pressure between the medium pressure source and the high pressure source.

7. A workpiece support device according to claim 5, in which in the columns in which the rod is not to be extended, the still further valve connected to the low pressure source at the lower end of the cylinder is not opened, the main piston is therefore not raised and when the upper medium pressure valve is opened the main piston is forced downwardly to depress the trigger piston and close the high pressure connection, the high pressure, when reconnected, is insufficient to raise the trigger piston against the downward force applied by the medium pressure to the main piston and the rod remains in the retracted position.

8. A workpiece support device according to claim 5 in which all cylinders may be reset to the retracted position by exhausting all the bottom connections while maintaining the air supply to the top connections and can then be set to advanced position or maintained in retracted position as desired.

9. A workpiece support device substantially as hereinbefore described and illustrated with reference to the accompanying drawings.

The Patent Office

12

Application No: GB 9802734.5
Claims searched: 1-9

Examiner: Dave Butters
Date of search: 28 April 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): B3R

Int Cl (Ed.6): B23K, H05K

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	US 5609377 A (FUJI)	
A	US 4506999 A (TELESIS)	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.